

i-SAIRAS 99 Paper Submission

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TITLE: An Object-oriented Software Architecture for Planetary
Dexterous Manipulators

Planetary rover software tends to become very complex due to the rovers' complex hardware architecture, numerous scientific instruments, and the requirements for real-time determinism and efficiency. We developed an extendible object-oriented system decomposition and architecture to manage this complexity and to provide a powerful, robust yet easy set of tools for developers of higher level applications. We have implemented a version of this object-oriented architecture on the Mars prototype rover, Rocky 7, to assist us in implementing autonomous manipulation on the rover. This architecture is being adapted for the next generation Mars rover prototype.

Object-oriented design provides a powerful tool for developing a system architecture that can be used on a wide range of planetary rovers with varying hardware components. We have developed a flexible five-layer object-oriented system decomposition. At the lowest level is the hardware dependent device driver layer, which describes system components such as digital and analog I/O boards, cameras, framegrabbers, and motors. The second layer is a hardware abstraction layer that provides an object-oriented hardware independent interface to the device driver layer. The third layer implements the basic independent subsystem operations such as arm, mast, vehicle, and other instruments. Sub-systems can be tested independently using this layer. The intelligent behavior layer integrates and coordinates the different subsystems using a component framework that implements data flow components and finite-state machines. Such behaviors include vehicle obstacle avoidance for navigation, sensor-based manipulation, and so on. Finally, the highest level is the autonomous operations layer, where complete operations such as long-range path planning and navigation, sample acquisition of a specified target, instrument placement on a target several meters away can be executed.

Criteria such as code reusability, extendibility, and portability played a key role in the design.